

1 CLAIMS

2 What is claimed is:

- 3 1. A method for treating metal working fluid, comprising the steps of:
4 transferring the metal-working fluid into a heating vessel;
5 heating the metal-working fluid in the heating vessel to maintain the metal-working fluid at
6 an elevated temperature during a heating period;
7 agitating and aerating the metal-working fluid during at least a portion of the heating period;
8 transferring the metal-working fluid out of the heating vessel into a holding vessel after the
9 heating period; and
10 transferring the metal-working fluid out of the holding vessel.
- 11 2. The method of Claim 1 wherein the heating vessel is provided with a heating element.
- 12 3. The method of Claim 2, wherein the heating element comprises a closed-loop recirculating
13 heater with a finned heating tube positioned within the heating vessel.
- 14 4. The method of Claim 1, further comprising the step of cooling the metal-working fluid in the
15 holding vessel.
- 16 5. The method of Claim 4, wherein the holding vessel is provided with a cooling element.
- 17 6. The method of Claim 5, wherein the cooling element comprises a finned cooling tube
18 positioned within the holding vessel and a source of coolant.
- 19 7. The method of Claim 6, wherein the coolant is cooled air.
- 20 8. The method of Claim 7, wherein the source of coolant is a vortex tube for cooling the air.
- 21 9. The method of Claim 1 wherein the elevated temperature is between about 145° F and about
22 210° F and the heating period is longer than about 30 minutes.
- 23 10. The method of Claim 9, wherein the heating period is longer than about 60 minutes and the
24 elevated temperature is about 160° F.
- 25 11. The method of Claim 1, wherein a bottom portion of the heating vessel is provided with air
26 inlets and air flow through the inlets and through the metal-working fluid agitates and
27 aerates the metal-working fluid.
- 28 12. The method of Claim 11, wherein the air flow through the metal-working fluid is heated
29 prior to flowing through the metal-working fluid.
- 30 13. The method of Claim 11, wherein the air flow through the metal-working fluid flows out of
31 the heating vessel through a de-mister.

- 1 14. The method of Claim 13, wherein the de-mister comprises a centrifuge impactor.
- 2 15. The method of Claim 11, wherein the air flow through the metal-working fluid flows out of
- 3 the heating vessel through a filter.
- 4 16. The method of Claim 15, wherein the filter comprises a charcoal filter.
- 5 17. The method of Claim 11, wherein air flows through the inlets and through the metal-working
- 6 fluid by application of negative pressure to an air volume above the metal-working fluid in
- 7 the heating vessel.
- 8 18. The method of Claim 17, wherein negative pressure applied to the air volume above the
- 9 metal-working fluid in the heating vessel is supplied by at least one of a centrifuge impactor
- 10 and an air flow amplifier.
- 11 19. The method of Claim 1, wherein the metal-working fluid is transferred into the heating
- 12 vessel by applying negative pressure to the heating vessel.
- 13 20. The method of Claim 19, wherein negative pressure for transferring the metal-working fluid
- 14 into the heating vessel is supplied by an air flow amplifier.
- 15 21. The method of Claim 1, wherein the metal-working fluid is transferred out of the holding
- 16 vessel by applying positive pressure to the holding vessel.
- 17 22. The method of Claim 21, wherein positive pressure for transferring the metal-working fluid
- 18 out of the heating vessel and into the holding vessel is supplied by a pressure regulator.
- 19 23. The method of Claim 1, wherein the metal-working fluid is transferred out of the heating
- 20 vessel and into the holding vessel by at least one of: i) applying positive pressure to the
- 21 heating vessel; and ii) applying negative pressure to the holding vessel.
- 22 24. The method of Claim 23, wherein negative pressure for transferring the metal-working fluid
- 23 out of the heating vessel and into the holding vessel is supplied by an air flow amplifier.
- 24 25. The method of Claim 23, wherein positive pressure for transferring the metal-working fluid
- 25 out of the heating vessel and into the holding vessel is supplied by a pressure regulator.
- 26 26. The method of Claim 1, further comprising the step of reducing a concentration in the metal-
- 27 working fluid of at least one metal by passing the metal-working fluid through an ion-
- 28 exchange filter.
- 29 27. The method of Claim 26, wherein one of the at least one metal is cobalt.
- 30 28. The method of Claim 26, wherein the ion-exchange filter includes a sulfonated divinyl-
- 31 benzene-cross-linked polystyrene ion-exchange resin.

- 1 29. The method of Claim 26, wherein metal-working fluid from the holding vessel is
2 recirculated through the ion-exchange filter.
- 3 30. An apparatus for treating metal working fluid, comprising:
4 a heating vessel for receiving and holding metal-working fluid for treatment;
5 a heater for heating the metal-working fluid in the heating vessel;
6 an agitator for agitating the metal-working fluid within the heating vessel;
7 an aerator for aerating the metal-working fluid within the heating vessel;
8 a holding vessel for receiving and holding treated metal-working fluid from the heating
9 vessel; and
10 a transfer pump for transferring the metal-working fluid from the heating vessel into the
11 holding vessel.
- 12 31. The apparatus of Claim 30, wherein the heater includes a heating element provided within
13 the heating vessel.
- 14 32. The apparatus of Claim 31, wherein the heating element comprises a closed-loop
15 recirculating heater with a finned heating tube positioned within the heating vessel.
- 16 33. The apparatus of Claim 30, further comprising a cooling element provided in the cooling
17 vessel for cooling the treated metal-working fluid.
- 18 34. The apparatus of Claim 33, wherein the cooling element comprises a finned cooling tube
19 positioned within the holding vessel and a source of coolant.
- 20 35. The apparatus of Claim 34, wherein the coolant is cooled air.
- 21 36. The apparatus of Claim 35, wherein the source of coolant is a vortex tube for cooling the air.
- 22 37. The apparatus of Claim 30, wherein the agitator and aerator comprise an air flow source and
23 air inlets provided in a bottom portion of the heating vessel so that air flow through the inlets
24 and through the metal-working fluid agitates and aerates the metal-working fluid.
- 25 38. The apparatus of Claim 37, further comprising a heater for heating the air flow through the
26 metal-working fluid.
- 27 39. The apparatus of Claim 37, further comprising a de-mister, wherein the air flow through the
28 metal-working fluid flows out of the heating vessel through the de-mister.
- 29 40. The apparatus of Claim 39, wherein the de-mister comprises a centrifuge impactor.
- 30 41. The apparatus of Claim 37, further comprising a filter, wherein the air flow through the
31 metal-working fluid flows out of the heating vessel through the filter.

- 1 42. The apparatus of Claim 41, wherein the filter comprises a charcoal filter.
- 2 43. The apparatus of Claim 37, wherein the air flow source includes an source of negative
3 pressure applied to an air volume above the metal-working fluid in the heating vessel,
4 thereby drawing ambient air in through the inlets and through the metal-working fluid.
- 5 44. The apparatus of Claim 37, wherein the negative pressure source includes at least one of a
6 centrifuge impactor and an air flow amplifier.
- 7 45. The apparatus of Claim 30, further comprising an inflow pump for transferring metal-
8 working fluid into the heating vessel by applying negative pressure to the heating vessel.
- 9 46. The apparatus of Claim 45, wherein the inflow pump is an air flow amplifier.
- 10 47. The apparatus of Claim 30, further comprising an outflow pump for transferring metal-
11 working fluid out of the holding vessel by applying positive pressure to the holding vessel.
- 12 48. The apparatus of Claim 47, wherein the outflow pump includes a compressed air source and
13 a pressure regulator.
- 14 49. The apparatus of Claim 30, wherein the transfer pump includes at least one of: i) a source of
15 positive pressure applied to the heating vessel; and ii) a source of negative pressure applied
16 to the holding vessel.
- 17 50. The apparatus of Claim 49, wherein the source of negative pressure is an air flow amplifier.
- 18 51. The apparatus of Claim 49, wherein the source of positive pressure includes a compressed
19 air source and a pressure regulator.
- 20 52. The apparatus of Claim 30, further comprising an ion-exchange filter connected to at least
21 one of the heating vessel and the holding vessel for reducing a concentration in the metal-
22 working fluid of at least one metal.
- 23 53. The apparatus of Claim 52, wherein one of the at least one metal is cobalt.
- 24 54. The apparatus of Claim 52, wherein the ion-exchange filter includes a sulfonated divinyl-
25 benzene-cross-linked polystyrene ion-exchange resin.
- 26 55. The apparatus of Claim 52, wherein the ion exchange filter is connected to the holding
27 vessel so as to enable recirculation of metal-working fluid from the holding vessel through
28 the ion-exchange filter.
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